Towards sustainable management of rodents in organic animal husbandry

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Received 11 August 2004; accepted 3 November 2004

Abstract

From 26 to 28 May 2004 an international seminar was held in Wageningen, the Netherlands, about current knowledge and advice on rodent management on organic pig and poultry farms in Western Europe. This paper summarizes the discussions. Rodent management is necessary to protect the food production chain from health hazards to livestock and humans. Some organic farmers prefer biological rodent control, but since rodents can also transmit diseases this bears certain risks for the production of healthy livestock and safe food. Effective rodent management requires a thorough understanding of the biology of the pest species concerned. These can be divided into two groups: field rodents, such as voles, and commensal rodents like house mice and rats. The objective of managing field rodents is to minimize livestock exposure to these vectors, and to regulate their populations in case their density is expected to grow dramatically. Infestation of livestock facilities with commensal rodents can be prevented, but once they are present, their eradication must be aimed for. General elements of rodent management are (1) the prevention of rodent infestations through strategic actions such as modifying the habitat or rodent proofing of the buildings, (2) monitoring their appearance and population density, and (3) rodent control measures. A number of possible management actions is described to provide a basis for examining the measures' social acceptability, their economic and environmental impacts, and their efficacy.

Additional keywords: rodent control, organic farming, *Toxoplasma gondii*, rodenticides, food safety, population ecology

Introduction

From 26 to 28 May 2004 an international seminar was held in Wageningen, the Netherlands about rodent control strategies on organic pig and poultry farms in Western Europe. This seminar was organized to address and discuss the issues of rodent control in relation to the principles of organic farming, food safety, animal health, efficacy, costs and animal welfare and suffering. The seminar was financed through the European Union Sixth Framework Programme 'Quality of Low Input Food'. This paper first presents the state of the art in the field of rodent management and then provides a number of recommendations following from the discussions at the seminar.

State of the art

The need for rodent management is imperative for farm production systems. Rodents can be divided into two main groups: native field rodent species (e.g. *Microtus, Arvicola, Apodemus*) that are part of the wildlife fauna, and commensal rodent species. Commensal rodent species (in Europe: *Rattus norvegicus, R. rattus* and the *Mus musculus-domesticus* complex) have lived in association with humans for millennia, and their high reproduction rates and omnivory can lead to significant impacts (e.g. Meehan, 1984) by consuming or fouling stored agricultural produce, acting as disease vectors or destroying infrastructure. In many parts of the world, these commensal species are also able to live in fields and crops. In Europe, commensal rodents usually live in or near buildings, feed stations and shelters for farm animals. Major fluctuations in population density as have been reported for Australia and Asia (e.g. Singleton & Redhead, 1989; Hanski *et al.*, 2001; Jacob *et al.*, 2004) do not occur in Europe. Although commensal rodents in Europe, just like field rodents, respond to changes in food and shelter availability, the temporal variation in the human environment is smaller than the variation in field environments. As a result, the population density of commensal rodents generally fluctuates less than that of field rodent species. Under certain conditions, field rodent species can sometimes even show cyclic population dynamics. However, some field rodent species (e.g. *Apodemus*) do not show such pronounced interannual fluctuations as e.g. *Microtines*. Control actions are necessary if a field rodent population is expected to reach a density that is of economic concern to the farmer.

Rodents can transfer pathogens and parasites (e.g. *Leptospira* spp., *Salmonella* spp., *Campylobacter* spp., *Trichinella* spp.) to animals and their products, to farmers and (indirectly) to consumers of animal products thus causing food safety problems (Le Moine *et al.*, 1987; Muirhead, 1993; Kapel, 2000). Also, at a broader geographic scale, rodents can be potentially hazardous because they can transfer contagious animal disease agents between farms. Examples are porcine parvovirus (Joo *et al.*, 1976), Aujeszky's disease virus (Maes *et al.*, 1979), foot and mouth disease virus (Capel-Edwards, 1970; Epoke & Coker, 1991), *Listeria* (Iida *et al.*, 1998), avian influenza and leptospires (Le Moine *et al.*, 1987; Boqvist *et al.*, 2002). The consequence is that rats and mice cannot be tolerated in the food production chain, including livestock production, irrespective of the degree of infestation. Even a single rodent can be a vehicle for transmitting a disease between farms.

Rodents are often responsible for infrastructural damage, for example by gnawing on insulations. Besides, they can attract predators such as foxes (*Vulpes vulpes*) to intensive animal production units, which can result in high losses of young pigs and poultry. Rodents can cause a productivity drop (reduced weight gain and/or reduced breeding success) through harassing the farm animals (Caughley *et al.*, 1994). They can also be responsible for considerable feed losses and direct predation of young poultry and for wounding of livestock, especially the teats of lactating sows and the feet of chickens.

Trapping rodents using snap-traps is often applied. Also rodenticides are frequently used, as they are among the most effective and least expensive measures for rodent control in intensive agriculture. Most of the time these rodenticides are anticoagulants, which act by interrupting the vitamin K cycle in the liver microsomes (MacNicoll, 1986). As a result, the maintenance of a number of clotting factors is hampered, resulting in fatal haemorrhages after a few days. Based on their toxicity, these rodenticides can be divided into two groups: the first-generation compounds such as warfarin, which have lower acute but higher cumulative toxicity, and the second-generation compounds, developed in the 1970s and 1980s, with a higher acute toxicity (Buckle, 1994). House mice and black rats are not so susceptible to first-generation anticoagulants; Norway rats are susceptible to these agents, except in certain restricted areas where resistance to one or several anticoagulants may occur in some populations. Here, knowledge of the resistance situation is a prerequisite for the choice of an active ingredient. In areas where resistance of rodents to one or different anticoagulant rodenticides exists (parts of Europe, North America, Australia and Japan), a rodenticide with higher potency should be used (Greaves, 1994). Unfortunately the second-generation rodenticides pose a higher hazard for primary or secondary non-target poisoning and so their use is limited. Four factors determine the uptake of a rodenticide bait (Klemann & Pelz, 2004): (1) whether the rodents are neophobic (fear of new objects) or neophilic (inquisitive of new objects), (2) the population structure of the target rodent population, (3) bait palatability and (4) habitat structure. However, control measures effective against one or a few rodent species should have a minimal effect on other species. Some of these other rodent species may even be part of the protected wildlife fauna (Table 1).

Table 1. Potential, abundant and protected pest species in the Netherlands as considered by an expert panel.

Pest species in the Netherlands		
Potential	Abundant, but no pest	Protected
Commensal species		
House mouse (*Mus domesticus*)		
Norway rat (*Rattus norvegicus*)		
Black, roof or ship rat (*Rattus rattus*)		
Wild species		
Common vole (*Microtus arvalis*)	Bank vole (*Clethrionomys glareolus*)	Northern vole (*Microtus oeconomus*)
Water vole (*Arvicola terrestris*)	Pine vole (*Microtus subterraneus*)	Beaver (*Castor fiber*)
Musk rat (*Ondatra zibethicus*)	Harvest/dwarf mouse (*Micromys minutus*)	Yellow-necked mouse (*Apodemus flavicollis*)
Coypu (*Myocastor coypus*)	Field vole (*Microtus agrestis*)	Hazel dormouse (*Muscardinus avellanarius*)
Wood mouse (*Apodemus sylvaticus*)	Fat dormouse (*Glis glis*)	Garden dormouse (*Eliomys quercinus*)

For organic farmers, the presence of rodents on their farm is not always a problem, although they generally perceive rats as a bigger problem than mice (Leirs *et al.*, 2004). We therefore assume the threshold for starting rodent control to be higher among organic than among conventional farmers. However, in case a rodent problem emerges, traditional rodent control methods, such as the application of rodenticides, do not really fit in with the philosophy of organic farmers, although in the European Union they are allowed by the regulations that apply to organic farming (Anon., 1991; 1997). A survey in the Netherlands showed that 100% of the conventional farmers used rodenticides, against only 69% of the organic farmers (Kijlstra *et al.*, 2004). The organic farmers often preferred other methods such as the use of cats (Kijlstra *et al.*, 2004). However, it is possible that the mice and rats caught by these cats are intermediate hosts for parasites such as *Toxoplasma gondii*. This parasite is transmitted via the food chain and is known to alter the behaviour of infected rodents, making them less afraid of predators like cats (e.g. Berdoy *et al.*, 2000). These cats in turn can become the definitive host for the parasite, and excrements from infected cats can then pose a hazard to the health of farm animals and humans. *Toxoplasma* infection occurs if pigs and poultry accidentally ingest infective oocysts from the environment. Cats may shed more than ten million oocysts per day for 3 to 10 days after infection (Dubey *et al.*, 1995). Apart from the health risk presented by cats, there is no sound evidence that cats regulate rodent populations.

One of the preconditions of organic animal production systems is access by farm animals to outdoor environments. Other characteristics of organic production systems are the use of organic feedstuffs, restrictions in medicine use, lower stocking rates, and, as in the case of pigs, a higher weaning age, straw bedding, and roughage in the diet. Access by organic pigs and poultry to the outdoors will lead to a higher exposure to infective stages of both micro- and macro-parasites and to the transmission of disease through direct contact with wild fauna, compared with conventionally kept livestock. Cleaning and disinfection of the living environment is more difficult for organic production systems. So an increase in organic animal farms could potentially lead to increased prevalence of *Toxoplasma gondii* and other pathogens.

To prevent emergence of *Toxoplasma* and other potential food safety hazards, there is a clear need for rodent control that is in line with the philosophy of organic farming. The seminar was organized to come up with recommendations for organic farmers how to organize their rodent management. This management should minimize welfare problems associated with rodent control measures, and the risk of environmental contamination or poisoning of non-target species must be negligible. Furthermore, slaughterhouse monitoring combined with on-farm prevention strategies and consumer education on preparation of organic meat products (e.g. Oosterom, 1991) are necessary to reduce potential infection risks and ensure food safety of products from farm animals raised within animal-friendly production systems (Kijlstra *et al.*, 2004).

Proposed recommendations

Rodent pests belong to two different ecological groups. Field rodents, such as voles (*Microtus* spp.) are adapted to live in natural habitats. They become pests when appearing in crops and pastures, where they can be very prolific. The commensal rodents (house mice and rats) were brought into Europe with human settlement and the exchange of goods. With a few exceptions, they are adapted to live in artificial environments, such as feed mills and stables. The objective of managing field rodents is to minimize livestock's exposure to these vectors, and to regulate their populations in case their density is expected to grow dramatically. An infestation of livestock facilities with commensal rodents can be prevented, and in the case of their appearance eradication must be aimed for.

On traditional farms a rodent management plan is preferably set up according to the principles of Integrated Pest Management (IPM), in which various management actions are integrated to assure effectiveness, cost efficiency and feasibility (Singleton, 1997). Very often these actions depend on the use of chemicals. Some of the basic principles of IPM (habitat management, control of rodent movements and control of the rodent population using physical measures) can be applied on organic farms. A more appropriate and efficient approach is ecologically-based rodent management (EBRM). EBRM is an extension of IPM and was developed as a formal description of a sound ecological basis for developing integrated management strategies for rodent pests (Singleton *et al.*, 1999, 2004a).

During the seminar it was proposed that a sustainable rodent management plan consists of three general elements: prevention, monitoring and control.

Prevention

On conventional farms exclusion of rodents is one option, because potential commensal rodent access routes into farm buildings can be blocked using physical barriers. Field rodents only occur outdoors, where it is impossible to exclude rodents, but their numbers can be reduced in order to diminish direct contact with farm animals if there is a reasonable understanding of the ecology of the main pest species. In general, all rodents often use specific habitat elements more frequently than the ones in a heterogeneous landscape typical of animal farms. For example, piles of old material that the farmer stores on his property because he thinks he might use it again, are often important burrowing and nesting requisites for rats (*Rattus norvegicus*) (Endepols *et al.*, 2003). Removal of such piles in concert with other management actions will decrease the risk of rodent infestation. Stacks of straw or hay may also form a good habitat for both rats and mice and thus form a potential source habitat for dispersal of rodents to other parts of the farm.

Some rodent species burrow or hide under low-lying and ground-covering shrubs within the neighbourhood of human dwellings (Colvin & Jackson, 1999). From a rodent management point of view it would be best to cut such shrubs down, but on the other hand these shrubs are needed as hiding places and shade for organic poultry, and may contribute to local biodiversity. We therefore recommend to remove vegetation only in a 2-m radius around the buildings and to place gravel, which deters rodents. Where rodents are an intractable problem, the removal of hedges within 100 metres from farm buildings or pigsties could be beneficial (Leirs *et al.*, 2004). Such actions are likely to be effective because vegetation cover determines the perceived predation risk in small mammals. For example, house mice are known to adjust their feeding activity in farm environments according to this perceived risk (Ylönen *et al.*, 2002).

The presence of open drinking basins will attract rats, as do automatic feeders. Remnants of feed at outdoor feeding sites on organic poultry farms may be an important food-source for rodents, as is the case with silage. Practices that minimize spillage of feed and access by rodents to feed stations are recommended. The use of ultrasound and low-frequency devices, chemical repellents, fumigants and non-poisonous chemicals are not recommended for rodent management on organic pig or poultry farms because there is little or no published evidence supporting their efficacy in open environments. Moreover, ultrasound devices are known to disturb livestock (Algers, 1984).

Repellents may be effective under different farming circumstances when used to protect seeds or young trees (if the items to be protected are treated directly with the repellent) and fumigants may be a useful method as part of an IPM-approach.

Monitoring

Monitoring improves the decision-making process in the prevention of rodent infestations. The appearance and abundance of rodents can be estimated using a range of techniques such as trapping, ink pads, tracking plates with sand, non-poisonous baits or electronic devices (e.g. infrared cameras). The usefulness of the monitoring data is strengthened if a farmer is able to find out which rodent species is/are causing the greatest impact because each species has distinct behavioural profiles and ecological requirements. Such knowledge will therefore substantially influence the development of an effective rodent management plan (Singleton *et al.*, 1999).

Control

Even the smallest infestation with rats or mice may need to be treated to protect food safety and the health of livestock. However, farmers usually only take action if rodent population densities on their farm premises are above a subjective threshold. A rodent control plan is required to commence an effective rodent control and to provide documentation as demanded by regulations, auditors or customers. As for the monitoring component, progress is contingent on knowing which species are the major pests, understanding their ecology and taking into account the farming system used by particular farmers. Also of importance are the behavioural peculiarities of particular rodent species, the production calendar, and the differences in management within and between farms.

An example of rodent management on an organic pig farm: the Norway rat

During the seminar we used decision analysis techniques (Norton & Pech, 1988) to determine the most appropriate methods for managing an infestation of the Norway rat (*Rattus norvegicus*) on an organic pig farm (Table 2). The table provides an example of an approach to assess different management options for one target species, the Norway rat, which may be an important vector of diseases.

Rodents have the ability to breed rapidly, so effective control should lead to high levels of mortality in the resident rodent populations on the farm to avoid the populations from quickly returning to pre-control levels. Rodenticides are the most efficient way to control an existing high-density population of the pest species. The control of field rodents with cyclic reproduction is most effective if commenced as soon as indicators show the onset of a reproduction cycle. This approach can prevent the development of high population densities.

Rodenticide usage thereafter can be minimized through strategic baiting, such as placement of bait stations in key places of the habitat (refuge and/or breeding places) (Table 2). Such a strategy requires a thorough understanding of the ecology of the major rodent pest species.

If an organic farmer does not want to use rodenticides, trapping seems the best alternative, although the labour needed to place traps around the farm premises and their checking may be costly. Other options are the use or encouragement of predators such as mustelids, cats and dogs. Unlike cats, dogs are less likely to be carriers of zoonotic diseases like *Toxoplasma gondii*, although they may carry *Echinnococcus multiocularis*. An extra action for organic farmers who do not want to use rodenticides could be the placing of perches or nest boxes on their property to stimulate the presence of birds of prey and owls such as the common buzzard (*Buteo buteo*), little owl (*Athena noctua*) and kestrel (*Falco tinnunculus*). However, the evidence that predatory

Table 2. Analysis of actions for managing the Norway rat on an organic farm in the Netherlands. This table is an adapted example of species-specific decision analysis of rodent control strategies.

Action					Acceptability			Practical[1]
Type	Place	Time	Efficacy	Cost	Organic[2]	Social[3]	Environmental[4]	
1st generation rodenticide	Key habitats	If high numbers are present	++[5]	Low	+/–	+	+	+
2nd generation rodenticide	Key habitats	If resistant to 1st generation and not close to waterways	++	Low	+/–	+/–	–	+
Trapping	Key habitats	If high numbers are present	+/–	Very high	+	+/–	Live traps: + Snaptraps: +/–	+
Shooting	Upon sight	Dusk and dawn	–	Medium	+/–	+/–	+/–	+/–
Cats	n.a.[6]	Always	–	Very low	+	–		+
Dogs (e.g. fox terriers)	n.a.	Always	–	Very low	+	+	+/–	+
Nest boxes & perches (birds of prey)	Fields	Always	+/–	Low	+	+	+	+
Domestic mustelids	n.a.	Always	–	Low	+	+	+	+

[1] Practical = whether a farmer can readily integrate the action into his farm management calendar.

[2] Organic acceptability = whether the action fits into the organic farming philosophy.

[3] Social acceptability = whether the action is accepted by society in general.

[4] Environmental acceptability = whether the action has detrimental effects on other species in the vicinity.

[5] ++ = very good; + = good; +/– = reasonable; – = very low.

[6] n.a. = not applicable, impossible to appoint a specific place for this strategy.

birds can effectively regulate rodent populations for extended periods is not strong. In case of organic poultry farms, attracting birds of prey could even result in predation of laying hens or broilers.

The above suggestions of possible actions, either alone or integrated, are merely suggestions. Studies have demonstrated effective eradication of rodent populations on farms following intensive once-off rodenticide use (e.g. Endepols *et al.*, 2003). However, whether effective, affordable and socially acceptable rodent management actions can be sustained under the conditions of organic farming has not yet been tested. Replicated field experiments on an appropriate scale are urgently needed.

Conclusions

Food safety is an important issue in animal production systems. In organic animal husbandry, farm animals will have closer contact with rodents and other wild animals than in conventional systems where animals are not allowed access to an outdoor area. Also, because of outdoor access, it is more difficult for organic farmers to prevent rodents from entering their buildings. This may potentially cause problems with contagious animal diseases and parasites that can be harmful to the health of both humans and animals. This alone should be reason enough to control rodent populations, but their significant damage to farm infrastructures and feed storage facilities makes rodent management even more necessary.

Effective rodent management requires a thorough understanding of the ecology of the main pest species. Based on this knowledge rodent management should consist of three elements: prevention, monitoring and control. From an organic perspective, most efforts should be invested in prevention and monitoring.

Organic farmers should select a solution that guarantees food safety and healthy livestock and that fits in best with their own farming philosophy. However, farmers should be aware that the often-applied use of cats as rodent control measure, can threaten animal health and food safety. A series of possible management actions is described but the socio-economics of these actions need to be examined. Methods of economic analyses for management of field rodent populations have recently been described (Stenseth *et al.*, 2003; Singleton *et al.*, 2004b). We strongly recommend that ecologically-based actions be tested in a replicated study through farmer participation using an adaptive management framework.

Acknowledgements

The seminar and this resulting paper were funded by grants from the European Union project Quality Low Input Food and the Dutch Ministry of Agriculture, Nature and Food Quality (LNV programme PO-34). The authors are grateful for the opportunity that was provided to discuss this important topic during the seminar.

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